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Evidence of persistent surge in Atmospheric Warming in IJEBU-ODE Metropolis

Aiyelokun Oluwatobi Oluwaseun

Department of Civil Engineering, University of Ibadan, Ibadan, Nigeria
aiyelokuntobi@gmail.com

ABSTRACT:
The persistent increase in carbon dioxide in the atmosphere has caused climate features to change. The study investigated the extent of surge in the atmospheric temperature in Ijebu-Ode metropolis using Parametric and Non Parametric statistical tools. Secondary data of atmospheric air temperature was obtained from the Nigeria Meteorological agency (NIMET) Ijebu-Ode, Ogun state station, which covers thirty-one (31) years. Results show that temporal air temperature trend had remained generally on the increase, with highest observation between 2003 and 2013. Analysis of Variance (ANOVA) revealed that there was a significant variation in atmospheric warming, while the Mann Kendall test shows that there was a significant positive trend in atmospheric warming in Ijebu-Ode (Kendall's tau = 0.308; $p<0.05$). The study concludes that there is need to encourage activities that ensure cleaner atmosphere and greener environment with the goal of enhancing sustainability in developing countries where impacts of climate change are more felt.

Keywords: Global Warming, Temperature, Variability, Parametric, Trend

INTRODUCTION

The persistent increase in carbon dioxide in the atmosphere has resulted in the surge of atmospheric warming. Changes in the state of the climate can be identified by using statistical tests for an extended period typically decades or longer [1]. Various researches have shown that for the past few decades, anthropogenic factors likes urbanization, deforestation, population explosion, industrialization and the release of greenhouse gases are the major contributing factors to the depletion of the ozone layer and its associated global warming and climate change [2,3,4,5].

Ahmad and Ahmed [6], IPCC [7], NEST [8] and Hengeveld et al. [9] provided indicators that one could use to assess the evidence of climate change in a region [10]. These include increasing temperature, increasing evapotranspiration, decreasing rainfall amount in the continental interiors, increasing rainfall in the coastal areas, increasing disruption in climate patterns and increasing frequency and intensity of unusual or extreme weather related events such as; thunderstorms, lightning, landslides, floods, droughts, bush fires, unpredictable rainfall patterns, sea level rise, increase desertification and land degradation, drying up of rivers and lakes and constant loss of forest cover and biodiversity [10].

Increasing temperature (global warming) in most parts of the world are the greatest impacts of climate change bringing about either negative or positive ecological impacts in different parts of the world [10]. The increasing temperature has led to increased land based ice instability and it's melting [10]. The thawing of the Arctic, cool and cold temperate ice, the increasing rainfall in some parts of the world and expansion of the oceans as water warms has started impacting on sea level rise, coastal inundation and erosion [10].

A major problem faced in developing countries is the absence of information to tackle inherent climate change induced challenges. Some of the tackling force which includes climate change mitigation, adaptation and vulnerability assessment may not yield adequate results if the extent of changing climatic elements is not known. This study endeavors to investigate the extent of surge in atmospheric warming in Ijebu-Ode using Parametric and Non Parametric statistical tools.

DESCRIPTION OF STUDY AREA

Ijebu-Ode is located approximately around latitude 6° 47° and longitude 3° 58°E in South Western Nigeria (Fig. 1). It has an area of 192 km^2 and a population of 154, 032 at 2006 census, it is bounded in the North by Ijebu North, bounded in the East by Ijebu East Local Government, bounded in the West by Odogbolu Local Government and in the South by Epe Local Government Council of Lagos State. The study area experiences humid tropical climate which is characterized by alternate wet and dry season seasons like the rest of Nigeria. Ijebu-Ode region on annual basis is under the influence of hot-wet tropical maritime airmass during the rainy season (April-October) and hot-dry tropical continental airmass during the dry season (November-March) the following year. Rainfall is

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generally heavy with peaks occurring in July and September (double maxima) coupled with high temperature, high evapotranspiration and high relative humidity. The mean annual rainfall is between 1575 mm and 2340 mm. The rains may be unduly prolonged in some years while their onset may be delayed as "AUGUST BREAK" is usually experienced between late July and Mid-August.

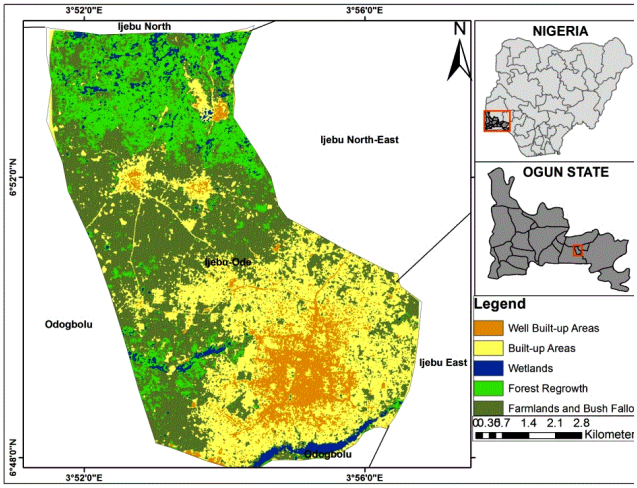

Fig. 1: Map of the Study Area

MATERIALS AND METHODS

Material

Secondary air temperature data was obtained from the Nigeria Meteorological agency (NIMET) Ijebu-Ode, Ogun state station. The time series of meteorological data covering 31 calendar years i.e. 1983-2013 was obtained. In order to investigate climate change in the study area, the data was segregated into three groups with coverage of a minimum of 10 years. That is, 1983 to 1992; 1993 to 2002 and 2003 to 2013.

Analysis of Variance (ANOVA)

The analysis of variance (ANOVA), also known as the F-test, is a method to determine the variation of the means of a group of data or variables to evaluate statistical significance [11]. The ANOVA test assumes a null hypothesis, which states that there is no difference between the data within a data set. The null hypothesis is rejected for the alternative hypothesis if the analysis is found to be statistically significant. The alternative hypothesis states that the means of the data in the data set are different. A 95% confidence interval was considered to be statistically significant. A P-value of 0.05 would classify as statistically significant. The ANOVA analysis was performed with the data segregated by a minimum of a decade to determine differences in mean atmosphere temperature of the study area which indicates climate change.

Mann Kendall's Test

The results obtained from the trend analysis were further verified by using a powerful and nonparametric Mann-Kendall Statistics (S) [12] developed by Mann [13] and Kendall [14]. The test uses the ranking of all the values to determine if there are more increasing or decreasing values in historical records. In the Mann-Kendall each test value x1 ... xn, are compared with all available values. For a positive difference between the data points the so-called S-statistics increases with +1 while it decreases with -1 for a negative difference.

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sgn\ (xj - xi) \quad \text{Eq. 1}$$

$$\text{Sgn (xj – xi)} \begin{cases} +1, > (xj - xi) \\ 0, = (xj - xi) \\ -1, < (xj - xi) \end{cases} \quad \text{Eq. 2}$$

$$\text{Var (s)} = \frac{n(n-1)\ ()\ \sum_{1=1}^{m} t1\ (i)(i-1)(1+5)}{18} \quad \text{Eq. 3}$$

Thus a large positive value of S indicates a strong positive (increasing) trend while a large negative value of S implies a negative (decreasing) trend. The nonparametric assumption of Mann-Kendall's test when used for a time series with a large number of values is documented which allow the use of a regular z-test to determine whether a trend is significant or not:

$$Z = \begin{cases} \frac{s-1}{\sqrt{\frac{n(n-1)(2n+5)-\sum_{j=1}^{9} tj\ (tj-1)(2t+5)}{18}}}, if\ s > 0 \\ \frac{s+1}{\sqrt{\frac{n(n-1)(2n+5)-\sum_{j=1}^{9} tj\ (tj-1)(2t+5)}{18}}}, if\ s < 0 \end{cases} \quad \text{Eq. 4}$$

where n = sample size; q= number of tied groups in the data set; and t_j = number of data points in the j^{th} tied group.

RESULTS

The results obtained for the study as well as its discussion are presented under this section.

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Descriptive statistics and Seasonal Variation of Temperature

The highest monthly air temperature for the study period occurred in the dry season (28.7° C in January to 30.11° C in March) and dropped sharply from April to August (26.06° C), before it rises in December (28.57° C) (Fig. 2). This indicates that average air temperature was generally high in the dry season and low in the wet season in the study area. More so, average temperature was generally low during August break when rainfall ceases.

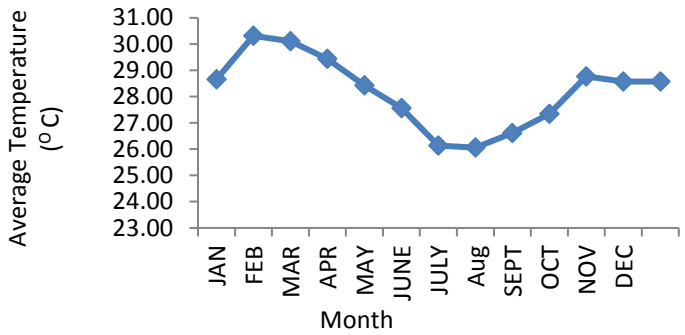

Fig. 2: Monthly Variation of Temperature

The air atmospheric temperature recorded in January, March, September, October, November, and December departed largely from their means (Sd = 1.5- 2.0 °C); while the remaining months had little deviation from their means (Figure 3). The months of May and August had the lowest standard deviation (0.8 and 0.9°C respectively), this implies that the lowest air temperature experienced during these months did not vary significantly during the study period.

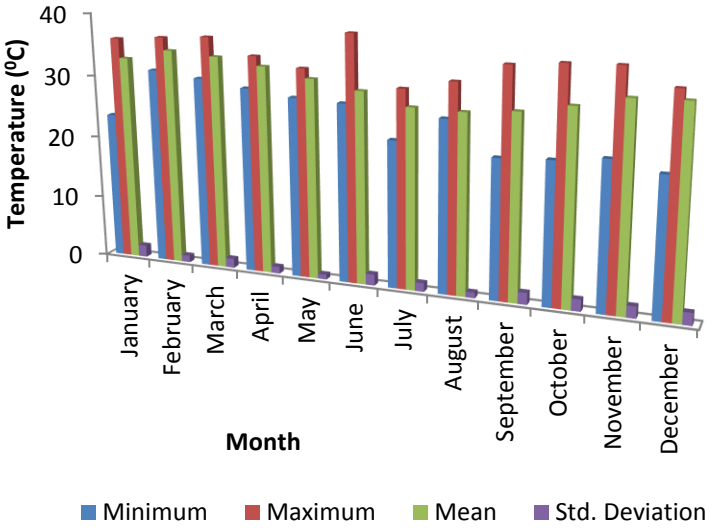

Fig. 3: Summary of Monthly Temperature

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Decadal Variability of Annual Atmospheric Temperature

Table 1 shows the means of atmospheric temperature for the different periods. The table indicates that as mean temperature increased within each category, the standard deviation reduced, implying that the mean atmospheric temperature in the last 11 years was higher than the former decades. In addition, the high temperature experienced in the last category had lowest standard deviation of 0.33 ^{0} C which means that temperature did not significantly deviate from the mean of 31.70 ^{0} C.

Table 1: Summary of means within segregated periods

Year	Mean (^{0} C)	N	Std. Deviation (^{0} C)
1983-1992	31.03	10	0.96
1993-2002	31.68	10	0.40
2003-2013	31.70	11	0.33

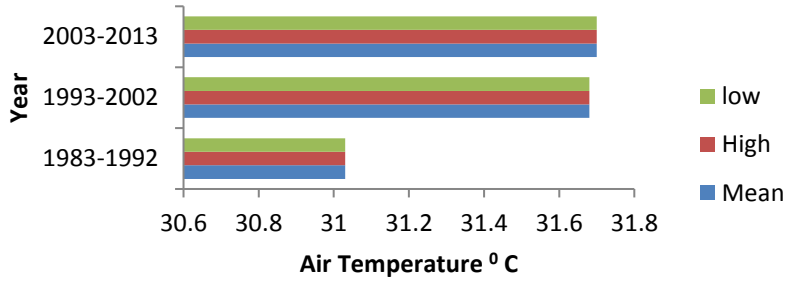

Figure 2: Decadal Trend of Variation in Air Temperature

The temporal air temperature trend had remained generally on the increase since 1983 (Fig. 2). The increase was highest 2003 and 2013. As shown in table 2, the significant p-value of 0.032 is less than 0.05. Hence the null hypothesis which says that there is no significant variation in the mean air temperature was rejected for the alternative hypothesis. Since the analysis is found to be statistically significant, it can be concluded that climate change is evident in Ijebu-Ode.

Table 2: Analysis of Variation in Air Temperature

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.005	2	1.502	3.908	0.032
Within Groups	10.763	28	.384		
Total	13.768	30			

The Mann Kendall test also shows that there is a significant rise in the pattern of atmospheric air temperature in Ijebu-Ode; this is confirmed by the Kendall's tau value of 0.308 ($p<0.05$) as could be seen in table 3.

Table 3 Summary of Result of Mann Kendall Test

Mann Kendall Statistics	Kendall's Tau	Var (s)	P-Value (Two Tailed Test)	Alpha	Remark
143	0.308	3459.7	0.016	0.05	This is positive significant trend

DISCUSSION

Many methods are available for calculating trend but the most common ones are the parametric least square regression techniques [15]. In order to confirm the indication of surge in atmospheric warming in the study area, statistical tools were employed which involved the parametric test (ANOVA) and non parametric (Mann Kendall trend) test. Thirty one years (1983-2013) temperature data for Ijebu-Ode South western Nigeria was studied. For the period under study the

temperature regimes for Ijebu-Ode appeared to have increased statistically and have remained generally on this trend. Both ANOVA and Mann Kendall test showed that the increasing trend was significant.

The sharp rise in temperature observed in the study area is in agreement with the global trend [1] as well as Nigeria trend [10]. The mean air temperature for the study period for the first decade (1983 - 1992) is 31.03 °C. In the 1993 - 2002 periods, the mean air temperature rose to 31.68 °C. By 2003 – 2013, the air temperature increased to 31.70 °C. NEST [8] provided indicators that one could use to assess the evidence of climate change in a region. These include increasing temperature, this study reveals that this indicator is already present in Ijebu-Ode, which is in agreement with recent studies [16,8,17]. Singer and Avery [18] posited that it is impossible for man to stop the natural causes of climate change but much can be achieved in either to stop or drastically reduce the human causes of climate change. One of such measure is to increase awareness of climate change locally.

CONCLUSION

This study investigated the indication of surge atmospheric warming in Ijebu-Ode using Parametric and Non Parametric statistical tools performed on annual temperature. It was observed that temperature varies with seasons, and was generally high during dry seasons. The ANOVA and Mann Kendall test showed that the increasing trend in temperature was significant. Hence, there is need to encourage activities that ensure cleaner atmosphere and greener environment with the goal of enhancing sustainability in developing countries where impacts of climate change are more felt.

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